The country's rising standard of living is another part of the changing equation. From the 1950s to the 1970s, only the smartest students could study abroad by qualifying for scholarships, says Jung H. Shin, an associate professor of physics at the Korea Advanced Institute of Science and Technology (KAIST) in Taejon. With greater wealth, however, a growing number of less exceptional students are able to study abroad by paying their own way.

A third important factor is what Yoon and most Koreans simply call "the IMF era." That's shorthand for the financial restrictions imposed on the country by the International Monetary Fund after the economic crisis of 1997–98. Before the crisis, Korea's *chaebol*, or business conglomerates, hired large numbers of Ph.D. candidates, often after their third year. But many researchers lost their jobs as their companies shrunk or went bankrupt, and few new slots have opened up. The downturn has contributed to a plunge in the proportion of high school students who say they plan to study science or engineering, from 50% in 1997 to 26% last year.

At SNU, a combination of those factors resulted in only 800 students applying this year for the university's 884 Ph.D. slots in the sciences. (The size of graduate programs is set by the government.) Some 632 were accepted—an enviable outcome for students, perhaps, but one not conducive to maintaining high standards. Many of these students may not go the distance, some scientists suspect, and others may be driven by forces other than a love of learning. "To be honest," says the 30-year-old Won, who is close to completing his Ph.D. in earth and environmental sciences, "about one-third of my decision to go to graduate school was because it exempted me from mandatory military service."

SNU is not the only science institution feeling the pinch. At Pohang University of Science and Technology, the proportion of undergraduates who plan graduate studies in science had dropped in the past 2 years from 79% to 61%. And last year at KAIST, says H. W. Lee, dean of academic affairs, "the chemical engineering program had no preliminary Ph.D. applications" from undergraduates, forcing professors to beat the bushes for a few worthy students. At the same time, Lee hastens to add, "our electrical engineering and computer science programs are doing extremely well," because Korea's computer industry has weathered the latest economic storm and is once again growing strongly.

But government officials aren't content to leave the country's technological future in the hands of market forces. In 1999 the government launched the Brain Korea 21 (BK21) program, which provides generous stipends for graduate students in addition to supporting their research and providing a travel allowance. "BK21 has really helped," says Won, noting that it allowed him to spend 6 months at U.S. and Japanese universities and attend several meetings. The overseas trips were an eye opener, he says: "When I was in America, I was surprised and happy to discover my education was at the same level."

But although Won looks forward to a research career in either the United States or Korea, he's part of an apparently shrinking minority. A recent survey of Korean junior high school students found that only 20% plan to study science or engineering in college; even at the country's elite science high schools, the figure is only 60%. Those numbers suggest a tough road for SNU and other universities promoting the value of graduate training in science.

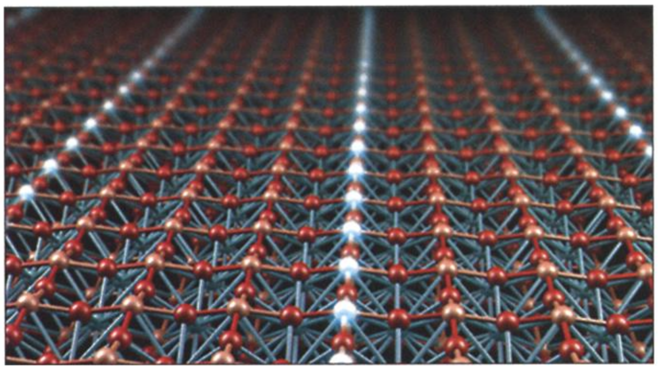
—MARK RUSSELL

Mark Russell writes from Seoul, South Korea.

SUPERCONDUCTIVITY

New Observations Give Stripes Theory a Lift

If three sightings make a trend, then a controversial theory of high-temperature superconductivity may have become a little more chic. The "stripes" theory states that current flows without resistance along lines of electric charge inside copper-and-oxygen–based superconductors. Such charge stripes had been spotted in only one superconducting material until two groups reported this month seeing them in two other superconductors, and a third group offered evidence that stripes do indeed conduct electricity.



Easy street. According to the stripes theory, holes fall into long lines along which they pair and move without resistance.

The new data indicate that stripes are a common feature of all so-called cuprate superconductors, says Steven Kivelson, a physicist at the University of California, Los Angeles, and a co-inventor of the stripes theory: "This means that this phenomenon is widespread. The evidence is crisp and clear." But others stress that the link between stripes and superconductivity remains murky, and some researchers think the new data reveal some more complicated pattern of charge.

For 15 years physicists have struggled to understand the cuprate superconductors. The materials consist of parallel planes of copper and oxygen atoms, with atoms of elements such as lanthanum, barium, and strontium sandwiched between the sheets. Sometimes an atom that is between planes will pluck an electron from a copper atom, leaving behind a positively charged "hole" that can move from copper atom to copper atom. Holes pair to glide along the planes without losing energy, but it's not clear how the like-charged holes manage to embrace one another.

The stripes theory provides a controversial explanation (*Science*, 19 February 1999, p. 1106). An isolated hole meets stiff resistance when it tries to hop from one copper atom to the next because the magnetic fields of neighboring copper atoms naturally point in opposite directions to create an up-down-up-down pattern. When an isolated hole moves, it disrupts this pattern, and that costs energy. To avoid the energy penalty, the stripes theory posits, the holes gather into stripes, which serve as little runways with no magnetism. Once in a stripe, holes can lower their energy even more by pairing.

Unfortunately for proponents of this theory, only one superconductor, lanthanum strontium copper oxide (LSCO), showed such activity. Now, three different groups are reporting similar results.

Herb Mook and colleagues at Oak Ridge National Laboratory in Tennessee have used a beam of neutrons to study the structure of a jumbo 25-gram crystal of yttrium barium copper oxide (YBCO), the most widely studied of the cuprate superconductors (*Science*, 1 February, p. 787). By carefully monitoring the reflected beam as the crystal rotates, the researchers detected stripes of holes lying along every eighth row of copper atoms, as they reported in the 4 March issue of *Physical Review Letters*. Meanwhile, Aharon Kapitulnik and colleagues at Stanford University in Palo Alto, California, used a tiny fingerlike probe known as a scanning tunneling microscope to study the surface of a crystal of bismuth strontium calcium copper oxide (BSCCO). They observed stripes of

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charge along every fourth row of copper atoms, as they report in a paper posted on the Los Alamos preprint server (arxiv.org).

Also, Yoichi Ando and colleagues at the Central Research Institute of the Electric Power Industry in Tokyo report that in nonsuperconducting LSCO and YBCO, the electrical resistance is smaller for current flowing in the direction in which the stripes are thought to run. That indicates the stripes are conductive, they argue in a paper to be published in *Physical Review Letters*.

Any theory that explains superconductivity in the cuprates must now account for their stripes, Kivelson says. But the larger question, says Douglas Scalapino, a theorist at the University of California, Santa Barbara, is whether stripes help superconductivity or—as most researchers believe—hinder it: "Do you really need these stripes? Or are the stripes something that compete with superconductivity?"

On the other hand, Shoucheng Zhang, a theorist at Stanford, argues that the pattern of charge in BSCCO looks more like a checkerboard than stripes. One-dimensional stripes may be a special case of a more general two-dimensional "charge ordering," Zhang says. If he's right, then next year's fashionable theories may exchange stripes for plaids.

–ADRIAN CHO

Adrian Cho is a freelance writer in Boone, North Carolina.

INDIA

Academic Science Gets Big Boost in Budget

NEW DELHI—Indian university researchers are cheering the government's new science budget, which includes a doubling of funding for academic infrastructure. The overall $300 million increase, to $1.5 billion, brings the R&D budget close to 1% of the country's gross domestic product; Prime Minister A. B. Vajpayee has pledged to raise it to industrial-world levels of 2%. Scientists are also heartened that the 25% growth in civilian science will keep pace with increases for atomic energy, space, and defense, which have historically received the lion's share of the country's research dollars.

"It's a very welcome sign," says Martanda Varma Sankaran Valiathan, a cardiac surgeon and president of the Indian National Science Academy. "And it was long overdue."

The budget, presented in Parliament on 28 February, awards a 52% increase to the Department of Science and Technology (DST). Within its $152 million allocation, the department plans to double the $10 million Fund for Improvement of Science and Technology, created in 2000–01 to augment laboratory instrumentation and facilities in universities. The fund is being extended to cover school libraries, including electronic databases. Indian scientists have complained bitterly in recent years about the steady erosion and aging of scientific facilities, and last year a draft of the government's Millennium Science and Technology Policy declared that "there is an urgent need to revitalize the scientific enterprise" (*Science*, 14 December 2001, p. 2269).

Last year the fund supported 180 science departments within 50 universities. But more than 1000 departments came up empty-handed. One successful application was from a group at North Eastern Hill University in Shillong, Meghalaya, which received an automatic nitrogen-15 analyzer to aid in their search for strains of cyanobacteria that could enhance the productivity of local rice farmers. "Without this sophisticated instrument, our work was really suffering," says Ramesh Sharma, head of the university's biochemistry department. The Tata Institute of Fundamental Research in Mumbai used the fund to help purchase a $5 million, 900-megahertz nuclear magnetic resonance facility for studying biological samples.

DST also plans to double its $10 million program for multidisciplinary basic science, with substantial funding for a new program in nanotechnology. Seismic research will get a boost with a $2.5 million airborne laser terrain-mapping project by the Survey of India in Dehra Dun. All in all, says Valiathan, the new budget suggests that the government has finally embraced the idea that basic research is as important as mission-oriented science in strengthening the country's economy.

–PALLAVA BAGLA

Good listener. Science minister M. M. Joshi (left) appears to have gained the ear of Prime Minister Vajpayee in this year's budget.

CREDITS: (TOP TO BOTTOM) CORBIS SYGMA; P. BAGLA

ScienceScope

Tower Study Pushed Engineers last week told the House Science Committee that it will take several years and at least $40 million to fully understand why the World Trade Center buildings collapsed after the 11 September terrorist attacks—and how other skyscrapers might be made safer.

Researchers began studying the fall of New York City's 415-meter-tall landmarks even before the dust had settled. But their investigations were hampered by bureaucratic infighting and lack of timely access to the site, witnesses told the committee. Despite such travails, a government-sponsored panel is set to issue a preliminary report next month. It is expected to conclude that jet fuel from the hijacked airliners ignited fires that weakened steel beams, causing the collapse. But panel head W. Gene Corley said more study is needed to understand "an event of this magnitude and complexity."

National Institute of Standards and Technology (NIST) chief Arden Bement said his agency—the government's expert on fire science and building materials—is already planning studies that would examine everything from steel dynamics to sprinkler-system design. Science committee chair Sherwood Boehlert (R–NY) and other lawmakers have asked the White House to fund NIST's plan quickly. Bush Administration officials have yet to respond, although they have approved the concept.

Victory Procured French scientists have won their long battle against byzantine government rules for procuring laboratory supplies. Research minister Roger-Gérard Schwartzenberg announced last week that he had convinced the finance ministry to jettison the guidelines, which forced researchers to get competitive bids and special approval for even relatively small purchases, such as cartons of test tubes (*Science*, 12 March 1999, p. 1613). Lab directors can now spend nearly $80,000 annually on a product without triggering a bureaucratic paper blizzard.

"We have won the battle," says Betty Felenbok of the Institute of Genetics and Microbiology in Orsay, who led a reform campaign that included a petition signed by 5000 scientists. "It is truly a happy ending."

Contributors: Xavier Bosch, Jocelyn Kaiser, David Malakoff, Michael Balter